RECORD LOW TEMPERATURES IN THE MID-ATLANTIC AND EAST CENTRAL STATES, OCTOBER 20-22, 1952

H. DEAN PARRY AND CHARLOTTE ROE

WBAN Analysis Center, U. S. Weather Bureau, Washington, D. C.

INTRODUCTION

Unusually cold weather engulfed a large portion of mid-Atlantic and east central United States, October 20 to 22, 1952. The cold outbreak yielded record breaking low minimum temperatures (fig. 1) for so early in the autumn at many places. Among these, Rochester, Minn., reported a temperature of 12° F. on October 20, Elkins, W. Va., observed a minimum of 11° on October 21, and Augusta, Ga., reported a lowest of 33° on October 21 and another lowest of 30° on October 22. The record breaking minimum of 23° which occurred at Dayton, Ohio, on October 21, was accompanied by a sea level pressure of 1037.6 mb., a new record for highest sea level pressure at that station.

The cold spell was unique because of its intensity rather than its synoptic pattern. As recently as October 18, 1948, a similar synoptic situation also set a few new temperature records. During October 1952, several of the 1948 records were superseded and a number of records established in former years were broken. It is our purpose here to discuss the synoptic aspects of the 1952 situation.

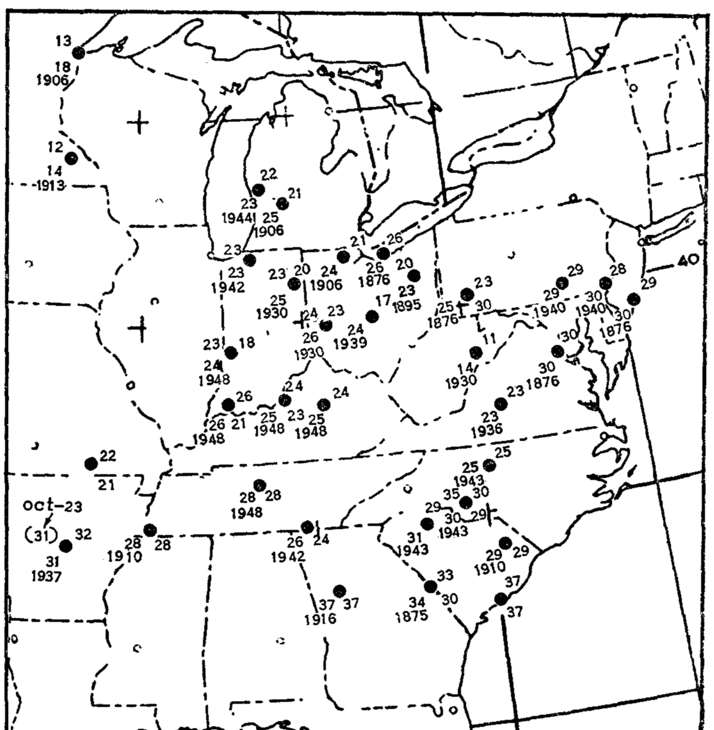

FIGURE 1.—Minimum temperatures (°F.) for selected stations in the mid-Atlantic and east central United States. Plotted figures indicate minimum for October 20, 1952 (upper left hand number), minimum for October 21 (upper right hand number), minimum for October 22 (lower right hand number), the previous record minimum for so early in the autumn and the year of occurrence (lower left hand numbers).

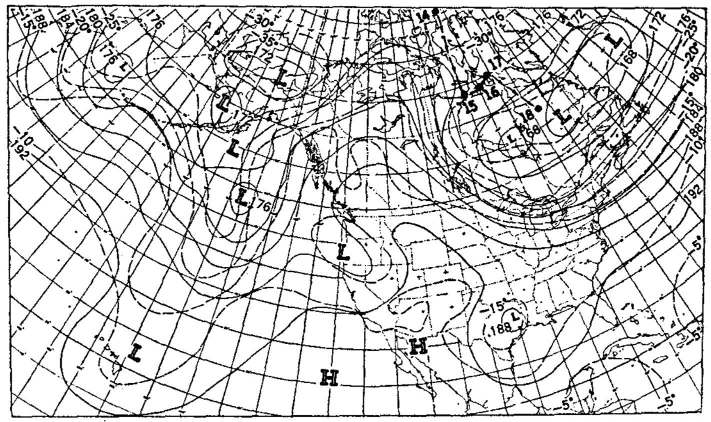

FIGURE 2.—500-mb. chart for 0300 GMT, October 19, 1952. Contours (solid lines) at 400-foot intervals are labeled in hundreds of geopotential feet. Isotherms (dashed lines) are drawn for intervals of 5°C. The track connects the 24-hour positions (GMT/date) of the center of the —40°C. isotherm.

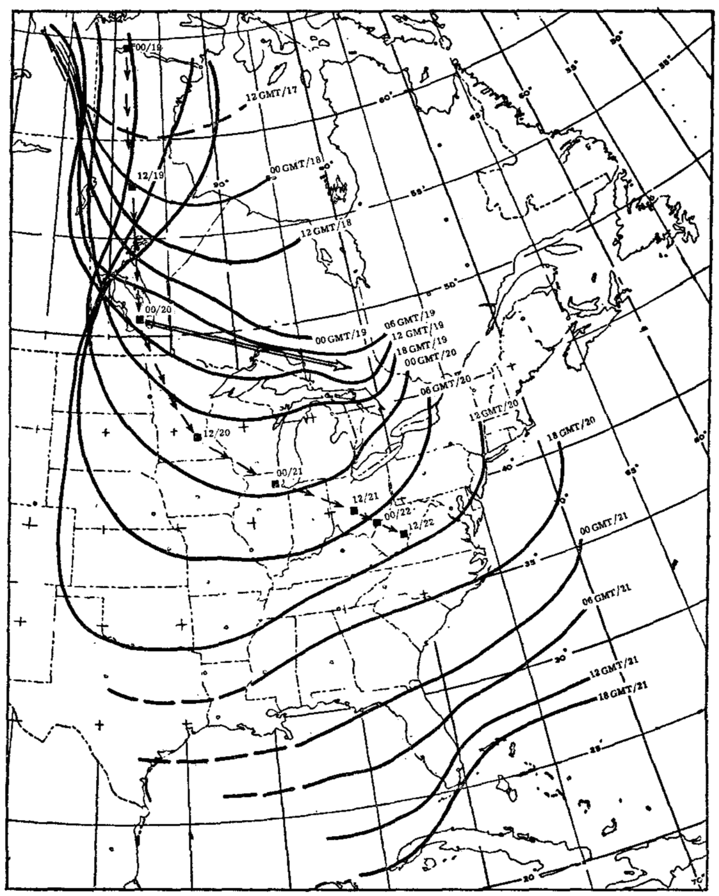

FIGURE 3.—Successive positions of the surface cold front labeled GMT/date. Track connects 12-hr. positions of the surface High center. Double shaft arrow indicates normal movement [5].

UPPER AIR CONDITIONS LEADING UP TO THE COLD WAVE

The upper air pattern which preceded this outbreak of cold air was characterized by strong northwesterly flow over the eastern part of the United States with anomalously high pressure over the Rocky Mountain area, and lower than normal pressures over the eastern United States. The dominance of this type of flow in the month's circulation pattern is shown by the mean 700-mb. charts for October and provides a basis for explaining the unusually dry and cool weather which occurred throughout the eastern half of the United States [1]. Furthermore the 5-day mean chart covering the period in which the cold outbreak took place shows a similar pattern.

Unusually cold air aloft appeared as early as October 13 over the Beaufort Sea. Figure 2, which includes the trajectory of the center of the −40° C. isotherm at 500-mb. during the period October 14–19, shows that cold air at 500-mb. moved rapidly southward from the 13th to the 15th. The cold air appeared to stagnate in the northern Hudson Bay area from October 15 through 17, but on the 18th resumed movement toward the south-southeast. By

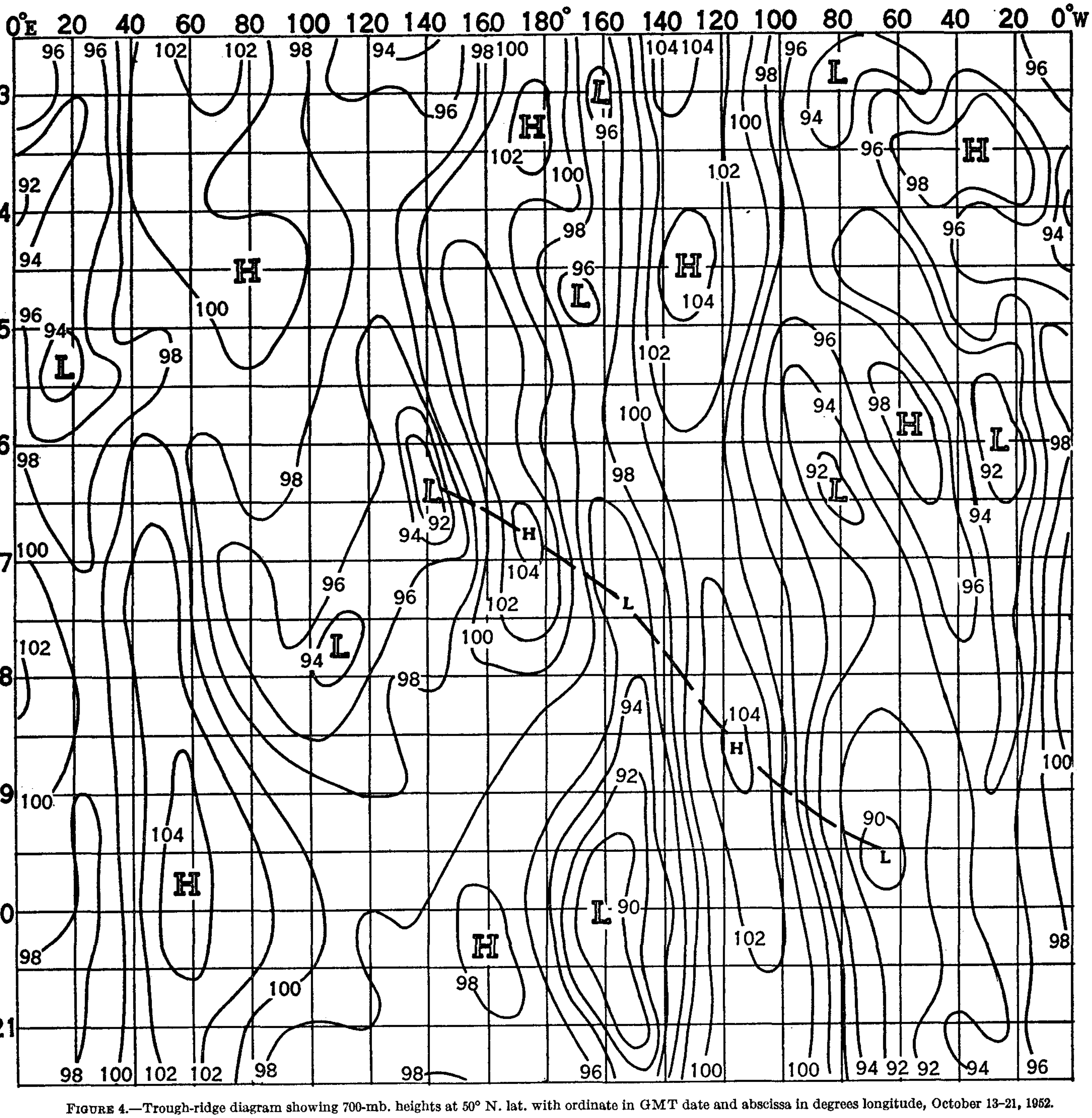

Figure 4.—Trough-ridge diagram showing 700-mb. heights at 50° N. lat. with ordinate in GMT date and abscissa in degrees longitude, October 13–21, 1952.

0300 GMT of the 20th the 500-mb. temperature at Sault Ste. Marie, Mich., had fallen to −40° C., or 23° C. below the normal temperature for October [2]. In spite of the general northwesterly flow into the north central United States throughout the month, this temperature was 7° C. lower than the temperature observed at this station at any other time during the month.

The trajectory of the surface High (fig. 3) was south or south-southeast during the period 0030 GMT, October 19 to 0030 GMT, October 21. In contrast to this, the more normal movement of Highs in that area [3] is east-southeastward as indicated by the double shafted arrow in the figure. This abnormal movement appears to be related to an unusually strong surge of cold air at 500-mb. which pushed southward into the eastern United States at this time. Although progress was rather halting during the early stages, this surge nonetheless became a potent factor in the synoptic situation on October 19–20 when it "steered" the High southward and set up a deep northerly current of cold air over the eastern United States.

Since the formation of the very sharp cold trough appeared to be a necessary attribute of the cold outbreak, it seemed worthwhile to investigate factors which may have been responsible for imparting an added impulse to the southward push of the cold air aloft. One such factor was suggested by the work of Rossby [4] and Yeh [5] who have discussed the transfer of atmospheric energy through dispersive waves. According to this theory the energy may travel faster than the individual waves and thus its effects, when they occur, can spread rapidly downstream. Hovmöller [6] has described a trough and ridge diagram by means of which this energy dispersal can conveniently be followed. For purposes of the present study, a modified trough-ridge diagram was constructed using 700-mb. heights at 50° N. Lat. (fig. 4). The semipermanent ridge at 115° W. is apparent and the persistent trough near 70° W. is also clearly shown. Superimposed on this pattern are the more transitory patterns. Of particular interest to the point under discussion is the series of alternate Highs and Lows connected by the dashed line on the figure. This pattern implies (1) that the formation of a deep trough at 140° E. built up a ridge at 180° some 12 hours later, (2) that the building ridge produced relatively low pressure at 150° W. some 15 hours later, (3) that this lowering of the heights at 150° W. built up pressures over the semipermanent ridge some 24 hours later and, (4) that the reinforcement of the ridge resulted in the deepening of the Low at 70° W. at 700-mb. on October 19, 0300 GMT. It must be kept in mind that this trough-ridge diagram is for latitude 50° N. only, and that the effects here discussed are not perfectly shown by such a chart. For example the Low which formed about 1500 GMT on October 17 actually formed several degrees south of the 50th parallel and therefore shows up rather imperfectly on the diagram.

Wobus and Norton [7] have studied the synoptic aspects of an energy transfer process that perhaps is somewhat

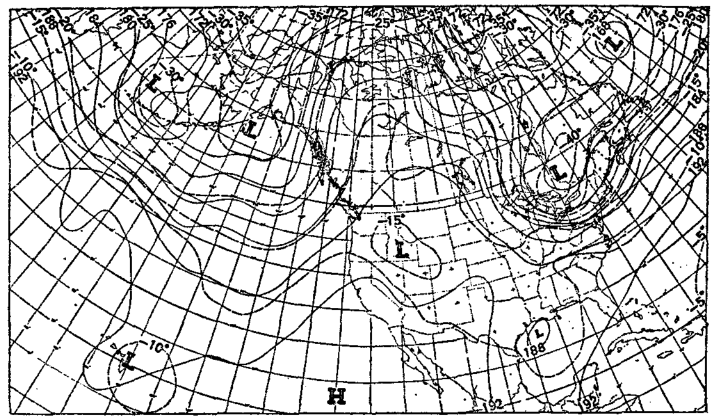

Figure 5.—500-mb. chart for 0300 GMT, October 20, 1952.

related to the process discussed above. Examination of the synoptic aspects of the present situation reveals a similar series of developments on the 500-mb. chart. The deepening of the trough north of the Great Lakes on the 20th (fig. 5) was not indicated by the approaching height changes at 500 mb. On the contrary, there were only weak 24-hour height falls of about 200 feet to the northwest of the trough at 0300 GMT on October 19. By 1500 GMT of the 20th falls of up to 600 feet had developed and were near the center of the trough. The increase in intensity of the katallobaric field seems to have resulted from rapid buildup of pressure north of 60° N. and near longitude 110° W. These rises set up the northerly flow which resulted in the "digging" [1] that deepened the trough. The rises in turn were not advected but developed as a result of the intensification of the trough in the Pacific from October 16 to 18. At 1500 GMT of October 18 the greatest rises near and to the west of the ridge in western Canada were 200 feet per 24 hours. These rises increased to more than 600 feet per 24 hours in the next 12 hours. The sequence of events as seen on the 500-mb. chart is then as follows: (1) the trough near 150° W. in the Pacific deepened, (2) this deepening strengthened the ridge over western Canada and, (3) this in turn deepened the trough over eastern United States on the 20th. The changes described above represent the synoptic aspect of the energy dispersion illustrated graphically by the trough-ridge diagram. These concepts have been found very useful in the preparation of prognostic charts in the WBAN Analysis Center over the past several years.

In connection with the conditions aloft, it is interesting to note that the most recent previous instance when the 850-mb. temperature at Nashville reached −4° C. in October (compared with −4.5° C. at 0300 GMT, October 21, 1952) occurred at 0300 GMT, October 18, 1948,

[1] The term "digging" is used in the WBAN Analysis Center to describe a situation in which winds (usually limited to winds having a northerly component) coming into an area are supergradient and as a result expend their excess kinetic energy in doing work against the pressure gradient. These winds, being deflected to their right, pile up air to their right and thus cause rising pressures there. Similarly a decrease of pressure results, to their left, in the area of "digging." This same relationship and variations of it have been described in the literature under various names (see [8, 9]).

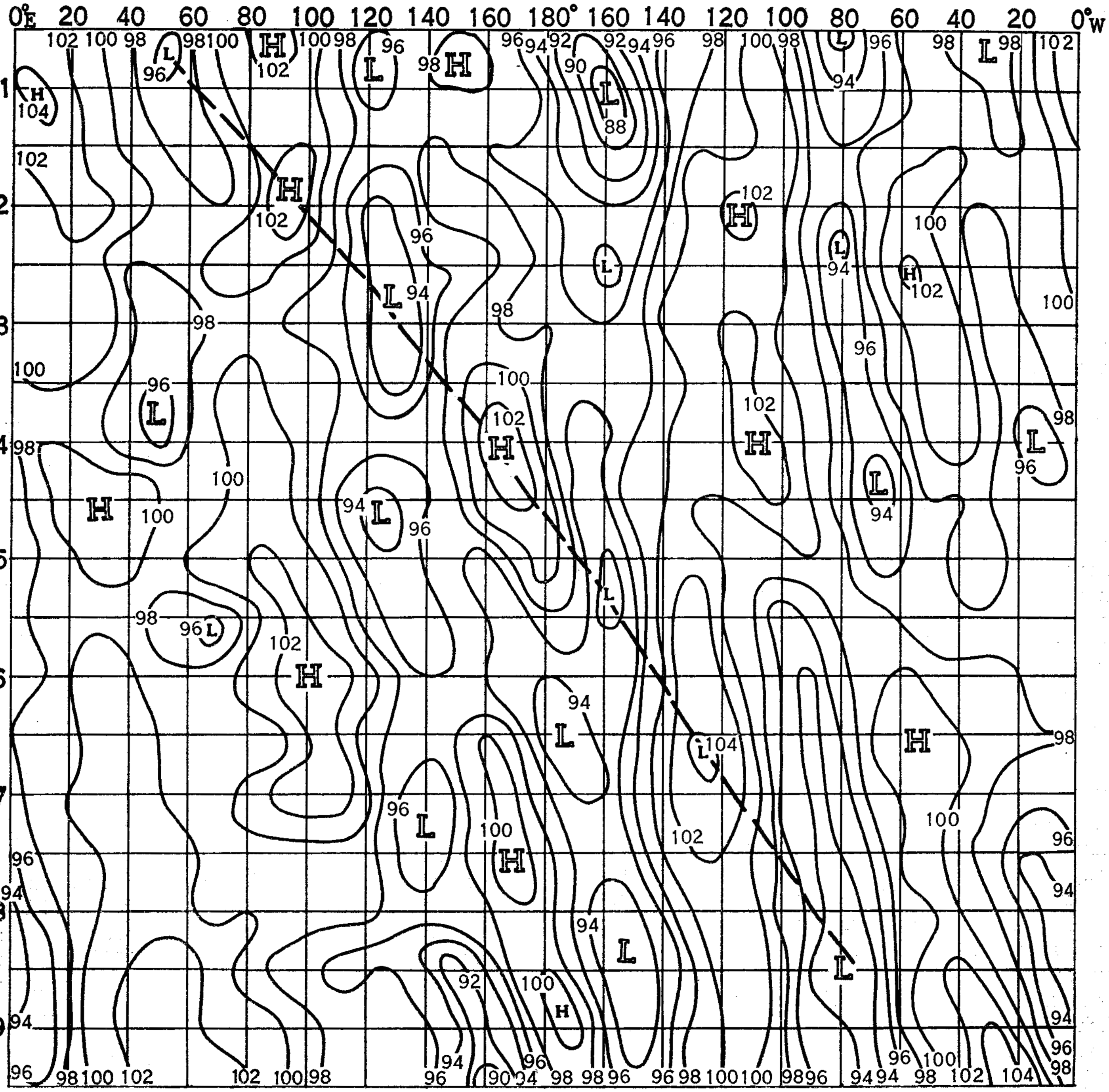

FIGURE 6.—Trough-ridge diagram showing 700-mb. heights at 50°N. lat., October 10–19, 1948. Coordinates as in fig. 4.

during the cold outbreak mentioned in the introduction. At that time the −10° C. isotherm at the 850-mb. level extended as far south as Sault Ste. Marie, Mich., and Joliet, Ill., but on October 20, 1952, 1500 GMT, the −10° C. isotherm was south of Joliet, Ill., Dayton, Ohio, and Pittsburgh, Pa. The similarity in the dynamics of the upper air development is readily seen by examining the trough-ridge diagram for October 1948 (fig. 6). Note the sequence of the trough-ridge effect beginning with a Low at 50° E. at 0300 GMT of the 11th. The series of Highs and Lows culminates in the ridge of 1500 GMT October 16 and finally the deepening trough of the 18th which brought the cold air southward. One may therefore infer in both instances that the broad scale upper air effects supplied a mechanism which "steered" the cold High southward.

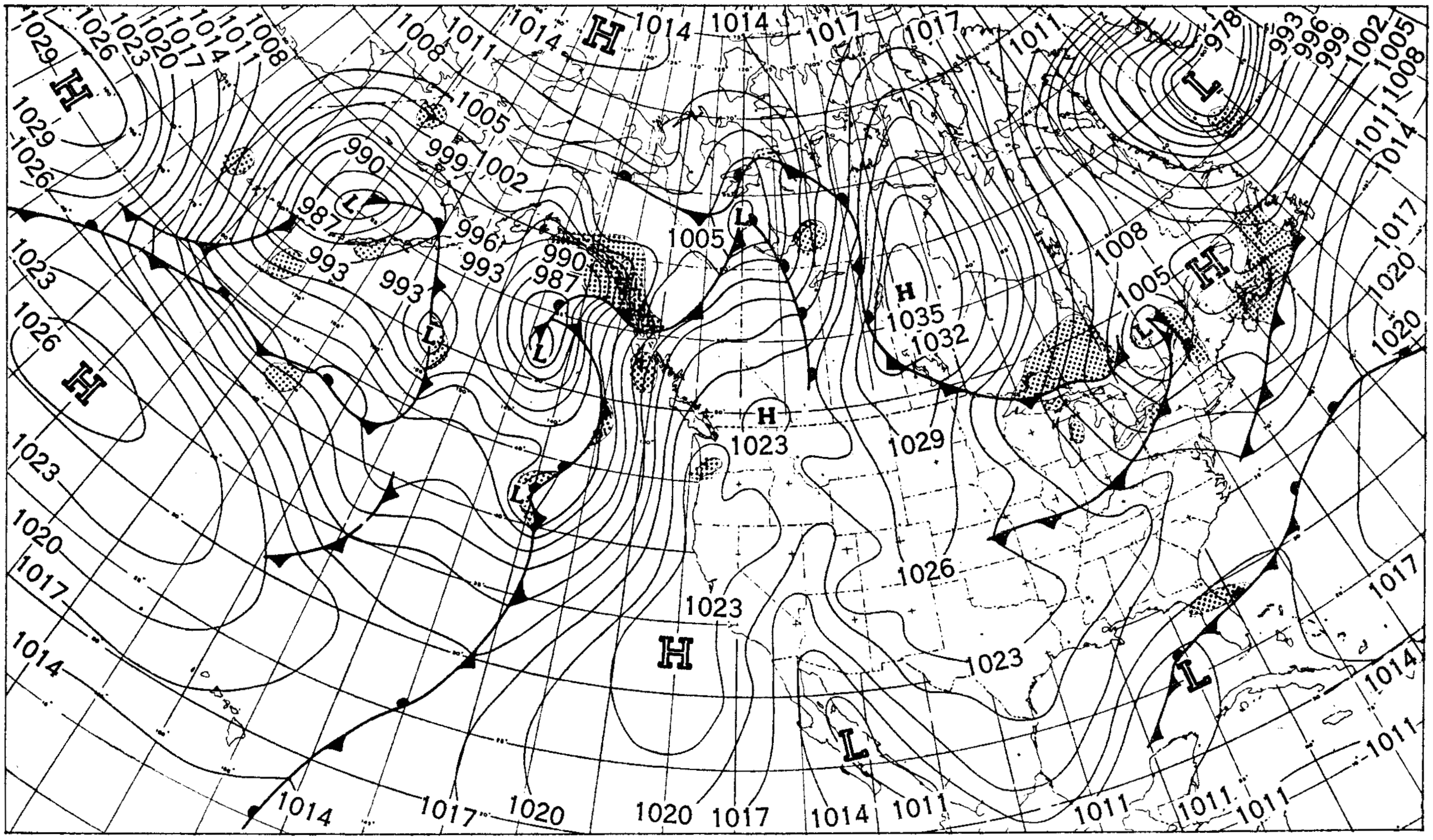

FIGURE 7.—Surface weather chart for 1230 GMT, October 19, 1952. Shading indicates areas of active precipitation. Isobars are at intervals of 3 mb.

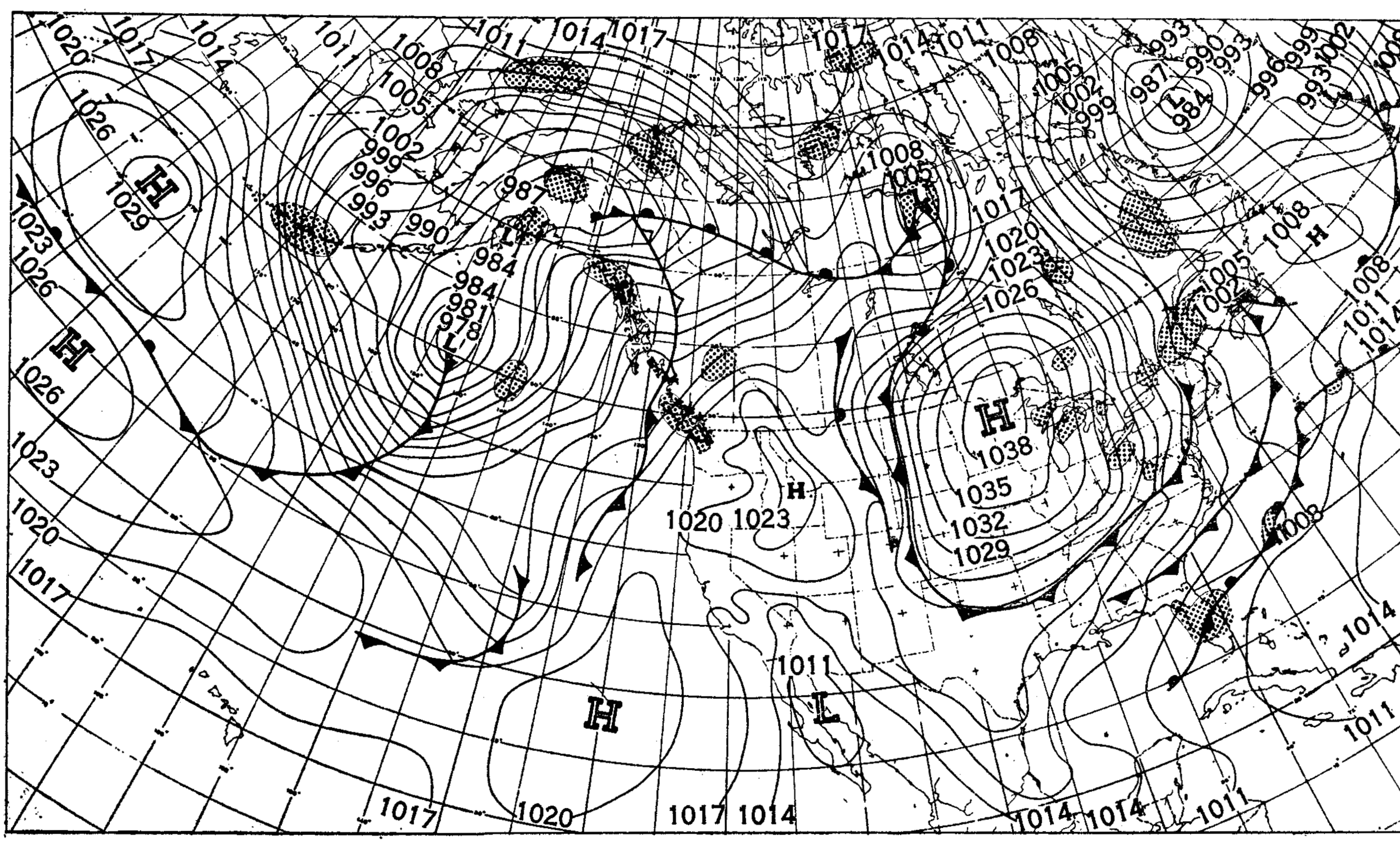

FIGURE 8.—Surface weather chart for 1230 GMT, October 20, 1952. Shading indicates areas of active precipitation.

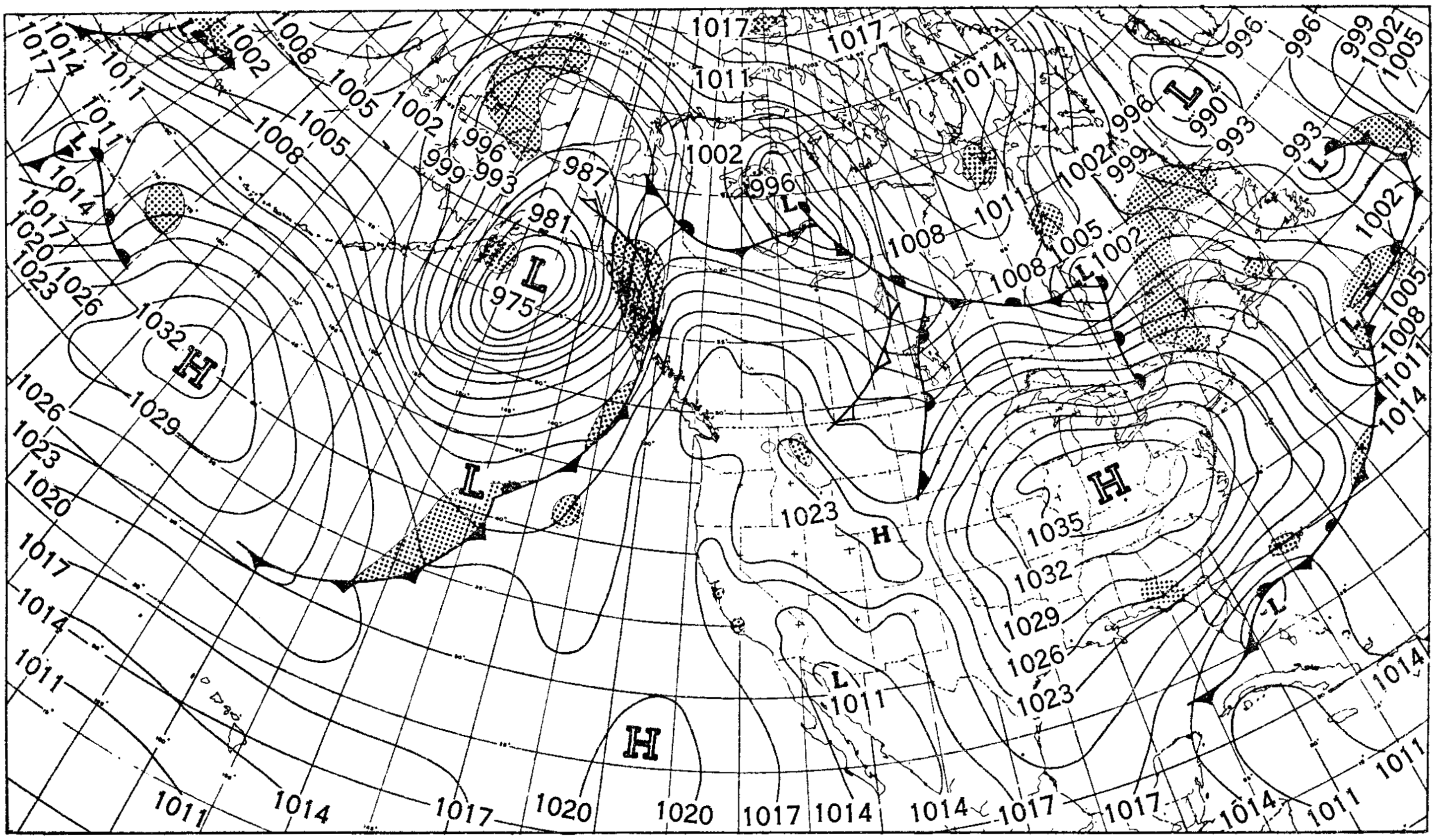

FIGURE 9.—Surface weather chart for 1230 GMT, October 21, 1952. Shading indicates areas of active precipitation.

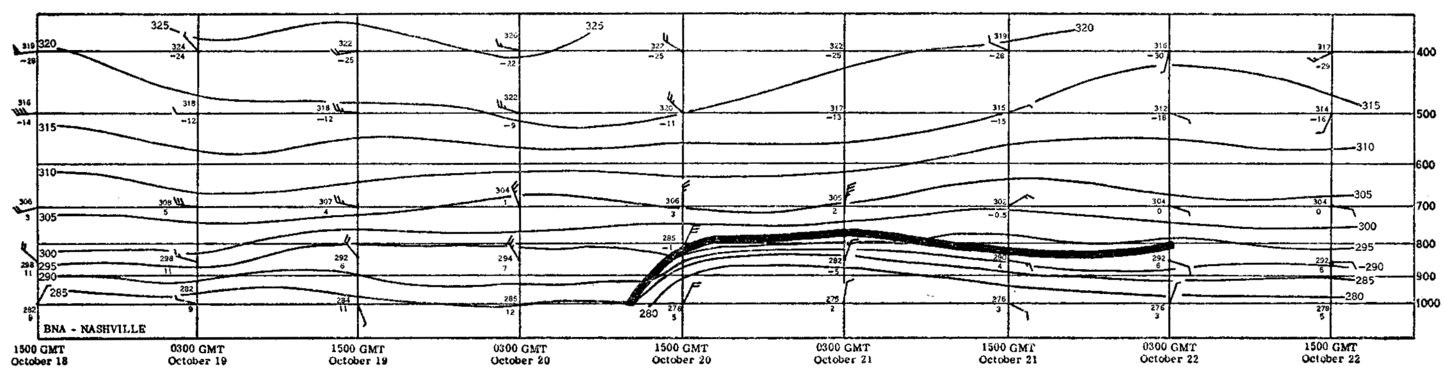

FIGURE 10.—Atmospheric time-height cross section for Nashville, Tenn., October 18–22, 1952. Barbs on wind shafts indicate speeds in knots; half barb=5 knots, full barb=10 knots, and pennant=50 knots. Wind shafts indicate direction as if plotted on a horizontal surface. Thick solid line is a cold front. Thin solid lines are isotherms of potential temperature (°A). The upper plotted numbers are potential temperature (°A) and lower plotted numbers, temperature (°C).

THE SURFACE CONDITIONS

The first appearance on the surface map of conditions favoring the cold outbreak was a cold anticyclone, which originated on October 18 over the area north of Hudson Bay (fig. 7). This High began to move rapidly southward bringing to eastern United States a large mass of Arctic air, which was extremely cold and extremely dry at all levels.

The High increased in intensity and reached a maximum pressure of 1041 mb. while centered near Minneapolis, Minn., 1530 GMT, October 20, 1952 (3 hours after time of fig. 8). Following this, the High continued to move southeastward, decreasing in intensity and decelerating. The center of the High remained west of the Appalachian Mountains (fig. 9) and at 1830 GMT, October 22, this High cell broke away from the westerly circulation and retrograded into Tennessee and Arkansas, where the center became diffuse.

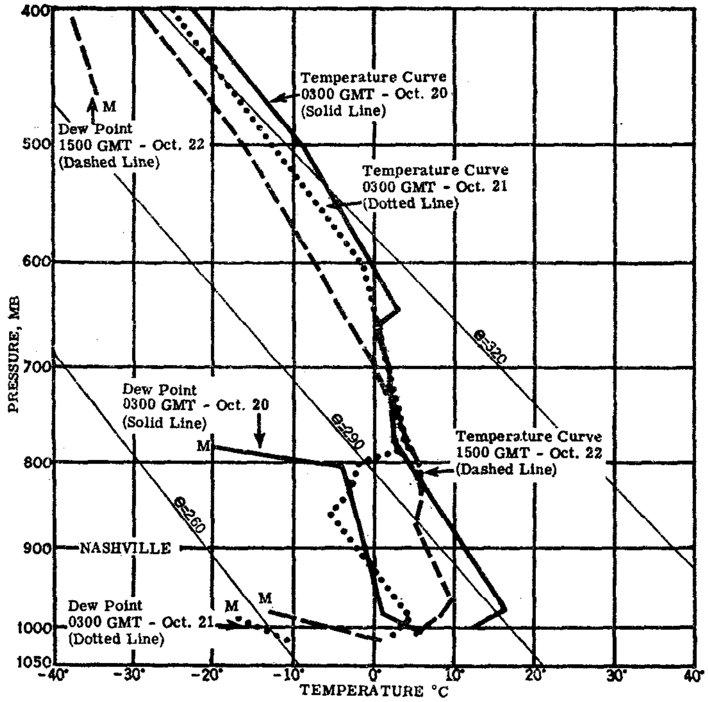

FIGURE 11.—Upper air soundings over Nashville, Tenn., October 20, 21, 22, 1952. "M" on the dew point curve indicates missing data due to "motorboating" (failure of the radiosonde instrument to record accurately due to the low moisture content of the air).

The intense anticyclone was preceded by two surfaces fronts (fig. 7). The first was a maritime polar front which entered the British Columbia coast as an upper cold front, but after crossing the mountains, assumed the characteristics of a surface cold front. Behind this polar maritime front was an Arctic front which originated in Canada at 60° N. Lat. as a rather diffuse boundary between the polar maritime and continental Arctic air. Figure 3 shows the successive positions of this front from the time of its initial southward movement in Canada to its leaving the United States. Snow cover, left by the passage of the front north of the Great Lakes, allowed little surface warming during the day and provided conditions ideal for nocturnal radiation.

The time-versus-height cross section for Nashville, Tenn. (fig. 10), shows the vertical structure of the front as it passed this station. In the cross section the strong gradients of potential temperature indicate the intensity of the cold front. Further evidence of the intensity of the frontal cooling is provided by figure 11, showing successive radiosonde ascents at Nashville. The intense frontal cooling in the layers below 800 mb. may be seen by comparing the soundings at 0300 GMT, October 20 and 0300 GMT, October 21. As the surface cold front moved southward into Florida (fig. 9), bringing below normal temperatures, gale force winds associated with the intense pressure gradient did considerable damage to shipping off the east coast of the State.

The Nashville soundings show that sufficient moisture was present in the air mass ahead of the front to activate the radiosonde humidity element to about 780 mb.

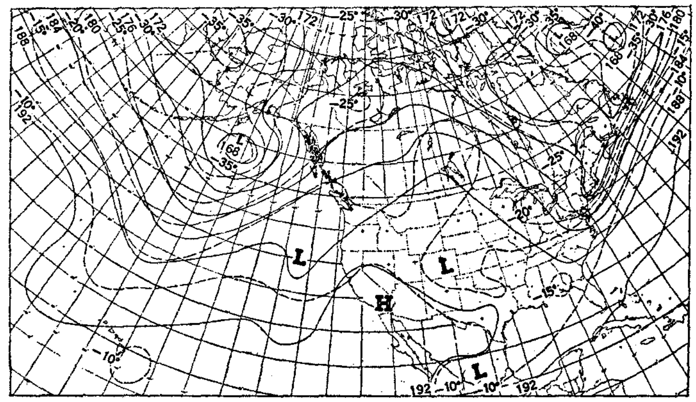

FIGURE 12.—500-mb. chart for 0300 GMT, October 21, 1952.

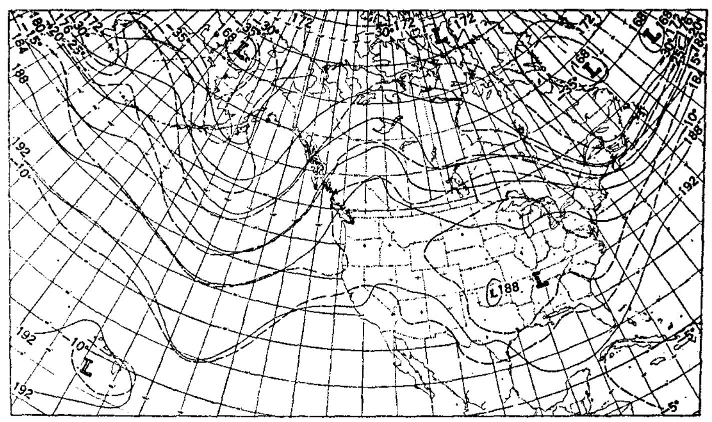

FIGURE 13.—500-mb. chart for 0300 GMT, October 22, 1952.

Twenty-four hours later (0300 GMT, October 21) with the passage of the front, the dew point curve indicates the air was much drier. Light winds and this extremely dry air were favorable for nocturnal radiational cooling.

Accompanying the low minimum temperatures were low maximum temperatures. In the northern portion of the eastern United States, these low temperatures were followed by a marked rise in both maximum and minimum temperatures on the following day due to warm air that came in aloft. The flow at 500 mb. (figs. 12 and 13) brought in a tongue of warm air north of the location of the surface High. This warning was in accord with the rule that the lowest minimum temperature at Washington, D. C., will usually occur the first night after the passage of the cold front. The "closed off" cold air remained over the surface High which became stagnant over the Tennessee-Arkansas area and brought a low minimum temperature of 31° F. at Little Rock, Ark., October 23, 1952, equaling the lowest so early in the autumn at this station.

CONCLUSION

The occurrence of record-breaking low temperatures October 20–22, 1952, has been related to the unique combination of upper air flow, surface pressure pattern, and ideal radiation conditions.

REFERENCES

1. J. S. Winston, "The Weather and Circulation of October 1952," *Monthly Weather Review*, vol. 80, No. 10, October 1952, pp. 190–193.
2. B. Ratner, "Upper Air Average Values of Temperature, Pressure and Relative Humidity Over the United States and Alaska," *Technical Paper No. 6*, U. S. Weather Bureau, May 1945.
3. E. H. Bowie and R. H. Weightman, "Types of Anticyclones of the United States and Their Average Movements," *Monthly Weather Review Supplement No. 4*, Washington, D. C., 1917.
4. C.-G. Rossby, "On Propagation of Frequencies and Energy in Certain Types of Oceanic and Atmospheric Waves," *Journal of Meteorology*, vol. 2, No. 4, Dec. 1945, pp. 187–203.
5. Tu-cheng Yeh, "On Energy Dispersion in the Atmosphere," *Journal of Meteorology*, vol. 6, No. 1, Feb. 1949, pp. 1–16.
6. E. Hovmöller, "The Trough and Ridge Diagram," *Tellus*, vol. 1, No. 2, May 1949, pp. 62–66.
7. H. B. Wobus and L. C. Norton, "Some Aspects of a Change in Weather Regime During February 1950," *Monthly Weather Review*, vol. 78, No. 2, Feb. 1950, pp. 31–40.
8. V. H. Ryd, "Meteorological Problems, I. Travelling Cyclones," *Meddelelser, Nr. 5*, Danske Meteorologiske Institut, Kjøbenhavn, 1923, 124 pp.
9. J. Bjerknes, "Extratropical Cyclones," *Compendium of Meteorology*, American Meteorological Society, Boston, Mass., 1951, pp. 577–598 (see p. 583).

U. S. GOVERNMENT PRINTING OFFICE: 1953